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Status and Assessment of Northumberland Strait Scallop Stocks

by

G.S. Jamieson
Fisheries & Oceans Canada
Fisheries & Marine Service
Resource Branch
Invertebrates & Marine Plants Division
P.O. Box 550
Halifax, N.S.

Introduction

The southern Gulf of St. Lawrence (ICNAF Subarea 4T) scallop fishery, although a relatively minor fishery in terms of total Maritime scallop landings (4.2% in 1975; 3.6% in 1976; and 1.7% in 1977), is predominantly a Northumberland Strait fishery (81% in 1976; 79% in 1977). Scalloping is a major fishery within the Strait, both in terms of number of boats actively involved (273 boats in 1978) and in dollar value ($1.3 million in 1976; $0.6 million in 1977). Recorded Strait scallop landings peaked in 1968 at about 885 MT of adductor muscle but have since declined to 187 MT in 1977. Catches are continuing low; and in 1978, when there was imposed a two-month summer scallop closure season to reduce effort and help preserve stocks, the total landing was about 200 MT. The only redeeming consideration is the all-time high price presently being paid for scallop meat (about $3/lb.) and the initiating of scallop meat-plus-gonad market development; the same price per pound was paid for meat and gonad, and since gonad weight, when of a quality to be marketable, is about 60% of meat weight, the economic return per animal fished is thus significantly increased.

To briefly summarize the history of the fishery, the declining status (Figure 1; Tables 1-3) of this fishery has been recognized for a number of years, and a number of meetings between fishermen and government representatives have been held in an attempt to reverse this trend. However, management concensus could never be reached; and as a result, the fishery remained

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unregulated until 1978, when government unilaterally imposed license and season restrictions, and suggested that gear type restrictions might be imposed in the near future. With minor modifications, these restrictions were tolerated by the majority of fishermen. Recognizing the need to create an effective forum for future discussion of management alternatives by all parties, a Northumberland Strait Scallop Advisory Committee was established in August, 1978, to provide management recommendations. This Committee will be meeting in mid December to formulate 1979 management recommendations, many of which will be based on data presented here.

There has been no systematic annual sampling of any scallops landed in the Strait, and so the data base on past stock characteristics is fragmented and incomplete. An intensive sampling program was initiated in 1978, with assistance from the Nova Scotia, new Brunswick, and Prince Edward Island Departments of Fisheries, and the P.E.I. Area Manager; hence, data from this one year alone provides much of our present knowledge on Strait scallop stocks.

Fishery Effort and Landings: Data Origin and Quality

Lobster fishing is the predominant fishery in the Strait and influences the level of effort expended in most other fisheries, including scallops. Scalloping predominantly occurs when the lobster fishery is closed; and since the Strait has a May-June lobster fishery in the east (Lobster District 7a) and a mid August-mid October lobster fishery in the west (Lobster

District 8), there is characteristically a western scallop fishery in the spring and an eastern scallop fishery in the summer and fall. Prior to 1978, when a mid July-mid September scallop closed season was first imposed, scallop landings were highest early in the scallop fishing period and gradually declined through the fishing season (Table 3).

Past data on the number of "actual" participants in the scallop fishery is of questionable accuracy, as sampling procedures (questionnaires) may have biased the results. Prior to 1972, an annual census of fishermen fishing in each fishery (Figures 2, and 3) was carried out on a voluntary basis, with each fisherman being asked to report what fishery he actively participated in. Unfortunately, many fishermen tended to routinely check off every fishery on the list. It should also be noted that the question asked was the number of fishermen which actively participated, not the number of boats; and no level of participation, such as weeks fished, was obtained.

This survey procedure terminated in 1972 because at that time a new survey technique was scheduled for introduction. However, four years later this new system had not yet been implemented and so in 1976, a repeat survey was made along the lines of the early surveys. In 1977, I requested through the Area Managers that the fishery officers estimate for 1976

the number of weeks spent scallop fishing for each fisherman in each statistical district (Table 4). In 1978, observers or fishery officers in most ports attempted to record, with varying success, days fished and landings for each fisherman.

Recent scallop landings appear to be of questionable accuracy as well, since it is estimated that a significant portion of the catch (30-50% pers. comm.) is not sold to registered buyers. No sales slips are thus prepared; and hence, this catch is not included in government landing statistics (Tables 1-3).

Present Fishery Regulations and Effort Levels

There are at present no regulations in the Strait on scallop maximum meat count, minimum legal scallop size, or gear specifications. Gear size is predominantly influenced by boat power, and it is reported that net liners in drags have been used in the past to catch smaller scallops. Until 1978, there were no license restrictions; but present regulations have frozen license number, prohibited license transfer, and will not permit license renewal for those men which acquired scallop licenses for the first time in 1978 and did not land scallops or make a significant financial committment to allow them to enter the fishery prior to October 5, 1978.

The vessels used in scalloping are multi-purpose vessels which are used in other fisheries as well, such as lobstering. The number of vessels which the region can support is thus influenced by the total productivity of all fisheries combined, and in itself is too large for the scallop fishery alone. Since there have previously been no scallop license restrictions, whenever the relative balance between the fisheries changed, either as a result of greater scallop recruitment or a decline

in recruitment in other fisheries, an excessive number of vessels for optimal management entered the scallop fishery. Any new recruitment was thus quickly depleted, often at a size well below that estimated to maximize yield per recruit (meat counts in excess of 100/lb. were reported in the Western Strait in 1976, pers. comm.). The numbers of present licensed and active fishermen in 1978 are given in Table 5.

Northumberland Strait Scallop Habitat

Sea scallops require a unique environment to maximize growth and productivity, and specific environmental requirements which appear important are:

1) Optimum substrate. Scallops are sedentary, and although capable of movement, this ability is predominantly a characteristic of young scallops which have a low shell weight:total weight ratio. Movement has also never been shown to be sufficiently directed to be considered migration. As a result, the success of initial larval settlement and survival is a major factor in determining an area's future productivity. Settlement and/or survival is suggested (Caddy, pers. comm.) to be improved by the presence of a well-established, microscopic, benthic community; and best survival appears to occur on gravel, as opposed to mud.

2) Optimum temperatures. As shown by their distribution in temperate waters, sea scallops are adversely affected by both cold and hot temperature extremes. Cold temperatures inhibit growth, and it is low winter temperatures which appear to result

in the more pronounced "growth rings" which characterize Gulf of St. Lawrence scallop shells; these rings are much less evident in Georges Bank scallops. Similarly, temperatures in excess of 20 C are likely to result in scallop mortality, and this has been documented (Needler, 1933; Chaisson, 1949; Dickie, 1951, 1958) as the major factor in some mass scallop kills in the 1950's.

It is temperature which appears to regulate depth preference, and thus in the Strait scallops tend to be concentrated at depths greater than 15 m. There seems to be no maximum depth in the Strait below which scallops are not found, perhaps because of the relatively shallow waters of the Strait (maximum depth is 48 m).

The net result is for scallops to be concentrated, and it is these concentrations which scallop fishermen actively search for. Once found, these areas are characteristically heavily exploited until either through capture, scattering, or indirect fishing mortality, densities are reduced to warrant further searching activity for less unexploited scallop concentrations.

There are reasons to believe that the Northumberland Strait is a less favourable environment for sea scallops than the Bay of Fundy off Digby, N.S., and much of Georges Bank:

1) The temperature regime in the Strait is much warmer in summer and colder in winter than in the other two major Maritime scallop fisheries. The Strait sea scallop fishery is one of the most northerly (46°00'N), consistently fished sea scallop fisheries in the western Atlantic, yet because of the enclosed

and shallow nature of the southern Gulf of St. Lawrence, this fishery is subjected to relatively high summer water temperatures (15-20+C). Growth is thus minimal in winter and relatively pronounced in summer.

2) Strait bottom sediments are generally muddier than the clean gravel or sand bottom favoured by sea scallops in other regions. Suspended silt generated by storms or concentrated dragging on this substrate may reduce survival by smothering small scallops or the microscopic benthic community needed for larval settlement and survival, and this could influence future recruitment.

Biological Characteristics of Northumberland Strait Scallop Stocks

A. Height-Weight Relationships

1. Adductor muscle

The relationship between height (= length in Haynes, 1966) of shell and weight of adductor muscle of sea scallops has been determined for Georges Bank and Gulf of Maine scallops (Haynes, 1966). Neither scallop sex nor location had a significant effort on this relationship, but significant differences were found between seasons for all but the eastern part of Georges Bank.

The only samplings of Strait scallop stocks on a regular basis throughout the season have been in the eastern Strait in 1976 and 1978. Scallop stocks in the western and central regions of the Strait have been sampled only in the spring of

1978 (Table 6). A significant seasonal difference was observed in 1976, with meat weight for a standard 90 mm scallop greatly reduced in July (Figure 4). June and August meat weights were about 11 g whereas the meat weight in July was 5.5 g. However, this pronounced, seasonal effect was not noted in 1978, when there was a gradual decline in muscle weight from April (13 g) to August (10 g) for a uniform size scallop. Meat weight relative to shell height appears lowest during July-August (Figure 4) and it would appear that annual and geographical differences may be important.

It is suggested that the particular temperature characteristics of a given year may greatly influence both growth and spawning activity, and that only through more detailed study of the energy budget and growth characteristics of scallops will a better understanding of this relationship be achieved.

For example, shell growth is greatest in early summer whereas muscle growth appears to be greatest in late summer. Thus, the suggested "decrease" in muscle weight, although real for a standard size scallop, may in fact simply reflect individual allometric growth for the population.

2. Gonad

The relationship between shell height and gonad weight has been determined for Strait scallops on a monthly and regional basis for 1978 (Table 6, Figure 4). In the eastern Strait, there may have been two or more spawnings, as gonad weights do

not significantly decrease until September. The gonad fishery in the western Strait terminated in late June because of poor gonad "quality" (pers. comm.), which appeared to result from partial spawning.

Geographical variability is again evident, thus emphasizing the importance of environmental factors in influencing both relative size and quality in this potential economically important product.

B. Yield Per Recruit

Von Bertalanffy growth parameters, as calculated from scallop samples collected between April-September, 1978, have been determined for Northumberland Strait scallops (Table 7, Figure 5). The growth rate is greater for young Strait scallops than that determined for young Georges Bank (Brown et. al., 1972) and Bay of Fundy scallops (Figure 5), and suggests that for the lower ages at least, this equation may not realistically describe growth in Strait scallops.

Mean age at first capture (Table 8) appears to be between three and four years, similar to that for Georges Bank scallops. Estimates of annual Z for the 1976-77 period appear similar to Georges Bank estimates (Caddy and Jamieson, 1977), showing a peak of about $Z = 0.7$ for age cohorts 4-5 and reduced values of $Z = 0.3$-0.6 for older cohorts (Table 9).

The higher Z value estimated for scallops of age 8-9 is not unusual in that it is not infrequent to find that there are two or more relatively abundant year classes on the same ground, in

a population, each separated from the other by a number of years. Significant exploitation of the youngest abundant year class (most numerous) is thus reflected by increased relative exploitation of the other abundant year classes as well.

Assuming M to be 0.1, then F is estimated to approximate 0.5-0.7 for age cohorts 3-5 and 0.2-0.4 for older age cohorts.

In 1976 and 1977, the most frequent age class caught by scallop gear was four-year old scallops; but in 1978, the most frequent age class was five-year old scallops. This suggests a decline in recruitment occurred in 1973, relative to that in 1972 but regardless, prevents accurate estimation of Z for the years 1977/78 using abundance percentage. Although the 1976 and 1977 sample sizes are disproportionate, this is the only relevant data, and so estimates of F from 1976-1977 data are used in subsequent analyses.

The results of the present yield per recruit calculations are presented in Figure 6. Maximum yield per recruit would occur at a mean age of first harvest between seven to eight years for fishing mortality rates of 0.6 to 1.5. Only very slight gains (1-2%) are achieved by delaying harvest after age seven. These results appear almost identical to that for Georges Bank scallops, but with a lower absolute yield per recruit.

Although the average current fishing mortality rate for three- to four-year old scallops approximates 0.5-0.7, it is quite likely that localized beds of scallops experience an F much greater than this, perhaps upwards of 1.5 to 2.0. However,

this can only be assessed through better identification of scallop beds and subsequent stock assessment, thereby stressing the need for improved fishery monitoring. This may also explain why Caddy's (1972) estimate of F for a localized area of Georges Bank is much higher than the estimated average F for the whole Bank (Brown et. al., 1972).

A further consideration is the unusual nature of the growth curve, which appears to overestimate yield for the younger age groups. If overestimations of 50%, 25%, and 10% are assumed for ages two, three, and four, respectively, then the yields (Figure 8) should be reduced proportionally.

At the estimated average F of 0.6, yield per 10,000 recruits for an age of first harvest of 3.5 years is thus estimated to be:

$$85 - (17.5\% \times 85) = 70.1 \text{ kg}$$

Decreasing effort to F = 0.3 would only increase yield by 8%, whereas increasing effort to F = 1.2 would decrease yield by 9%. Increasing age at first harvest to five and six would increase yields by 47% and 57% respectively. Maximum potential yield is 115 kg at age of first harvest of 7.5 and F = 1.0; this would represent a 64% increase over adjusted current yield estimates (70 kg), or a 35% increase if current yield (85 kg) is not weighted for possible overestimation at the younger ages of first harvest (see above).

It should be noted that the value M greatly influences the isopleth pattern, and that this value has not been accurately determined. A value of M = 0.1 appears realistic for Georges

Bank, but this may be an underestimate for the Strait. The frequency and magnitude of mass kills due to the high water temperatures is unknown, and the considerable numbers of rock crabs and lobsters, both potentially scallop predators (Elner and Jamieson, 1978), may also significantly influenc natural mortality.

Exploitation and Abundance

Because of their small gross tonnage (< 25.5), Northumberland Strait fishing vessels are classified as inshore and hence are not presently required by regulation to submit logs describing their fishing activity. Biologists have never in the past consistently collected catch or effort data from this fishery, and so past stock characteristics are somewhat speculative. Past height frequency and meat weight data have been reanalyzed in an attempt to ascertain whether or not a sufficient time series of data exists to estimate recruitment patterns, and it is felt that sufficient data is only available for the years 1974-1978 in the eastern Strait (Table 8). Data is from different sources but it appears to be sufficiently random to accurately reflect the relative age frequencies present.

The shift in most abundant year-class from four-year old scallops to five-year old scallops in 1978 indicates that a constant recruitment cannot be assumed to occur. This was expected, as this recruitment pattern characterizes many fisheries.

No seasonal or regional changes in age class abundance (Figures 9 and 10) respectively) were evident within the Strait in 1978. The lack of regional differences suggests that in contrast to Georges Bank, the year classes within the Strait are well mixed on presently fished scallop ground.

The lack of seasonal change indicates that during the 1978 fishing season, no specific age class was significantly depleted relative to the other age classes present.

Biomass Estimation

Estimates of meat yield per 15-minute tow are from two sources: length frequency data measured at sea from one tumble drag (Table 10), and data on average catch per boat and number of tows per day obtained from interviewing scallop fishermen in eastern P.E.I. (Table 11). These data are similar and suggest that scallop tows produce on average only 2-3 lbs. (1-1.5 kg) of meat per tow.

Estimating a four-gang drag to have a width of 3 m and an average tow length to be 926 m (15-minute tows at 2 knots), the total area covered per tow would be 2778 m^2. A typical catch is 100-150 and 200-225 scallops per tow (Table 10) in the eastern and western Strait respectively, and this suggests an average scallop catch of only 0.04-0.08 scallops per square meter fished. Estimates of areas fished were derived from Caddy (unpublished data, Figure 12), and total scallop abundance estimates are given in Table 12.

Weighting age frequency for yield (Table 13) indicates that in 1978, six-year old scallops contributed the greatest overall yield, although the most frequently fished scallops were five-years old.

Average seasonal and regional meat counts per pound (Table 14) indicate that in 1978 at least, meat counts were relatively low and averaged around 30-35/lb. This is suggested to reflect the relative low abundance of three- to four-year old scallops, as very high meat counts were reported in 1976 when young scallops were known to be numerous.

Management

As a result of the apparent decline in Strait scallop landings, a decision was unilaterally made by government in 1978 to freeze licenses and reduce effort by restricting scalloping to 2 two-month periods: May-June and September-October. Unfortunately, the license freeze was delayed while word went out that it was coming, resulting in even more licenses being issued in 1978 than in previous years (Table 5). Pressure from the fishermen, lately applied through the Northumberland Strait Scallop Advisory Committee, resulted in the opening of the fishery throughout the fishing season except for a two-month, mid-summer closure, which in 1978 extended from July 15 to September 15. A mid-summer closure was recommended because at this time, lobstering was minimized and hence more fishermen typically fished scallops.

Effort was thus maximized, and so closing the fishery at this time minimized the duration of closure required to achieve a constant reduction in effort. A further consideration was that on the basis of our 1976 shell height:meat weight data, yield per recruit was minimal at this time on a seasonal basis. This relationship was not as pronounced in 1978, but was nonetheless evident.

Recognizing that the Strait scallop resource is greatly over-exploited, a number of possible management alternatives exist which have the potential to increase yield.

1) License restrictions

Although new licenses are not being issued, the number of present licenses issued appears to exceed that required for optimum management. Only about 50-60% of licenses are actively used; and of these, perhaps only 50% again rely on scalloping for most of their income (Table 5).

Fishermen do not want to take the right to fish away from other fishermen, and so it is unlikely that their support can be obtained to greatly reduce in 1979 the number of licenses issued. It was difficult to reach agreement to prevent renewal of those scallop licenses issued for the first time in 1978 and which were not actively used in 1978 prior to October 5. Rather, preventing transfer of licenses and allowing licenses to be gradually retired appears to offer the only reasonable possibility if a policy of license restriction is felt desirable.

2) Effort restrictions

The generally poor status of existing stocks suggests that licensed individuals presently not engaged in scalloping will not likely rush into the fishery unless other fisheries decline significantly.

The options available here include a closed season(s) or regional quotas. With our present inability to accurately determine landings and the possible introduction of a fishery note system in 1979, quotas would appear impractical to implement. Regional quotas would have to be applied because of the different regional scallop fishing seasons in the Strait arising from the lobster fishing periods.

A closed season has the advantage in that all fishermen are treated equally, it is relatively easy to enforce, and it is readily tailorable to meet different annual requirements. There is also historical precedence in that a closed season was implemented in 1978.

However, since yield per recruit studies indicate that effort control is less effective than age of first capture control in improving yield, the value of season closure is maximized if it is timed over the spawning period or when temperatures are near the scallops' lethal limit. Minimizing scallop disturbance at these times might improve overall productivity by either maximizing recruitment or minimizing indirect fishing mortality.

3) Meat count regulations

Meat count regulations have been in force in the offshore fishery for six years, and there is evidence (Caddy and Jamieson, 1977) that it has improved yield per recruit. Because of the lack of fleet regulations in the Gulf and the apparent sporadic occurrance of significant recruitment, meat count regulation would appear to be the only practical method of preventing over-exploitation of young scallops and significantly increasing yield per recruit (47-57%). It should be noted that the Northumberland Strait Scallop Advisory Committee is presently in favour of meat count regulations and has specified that an acceptable initial meat count regulation should not be greater than 60 meats/lb.

Conclusions

1. A data base for adequate management of Northumberland Strait scallops is non-existent, and most of the data presented here is based on limited monitoring of commercial fishing activity for only one year. Detailed stock assessment is thus impossible at this time.

2. This lack of previous fishery data makes it difficult to evaluate in detail the effectiveness of the 1978 two-month scallop closure. However, there is evidence that anticipating the closure, expended effort was above average in early July and would likely have been so in the fall as well were it not for poor daily landings. The effectiveness of the closure was also compromized by the conflicting statements issued during the year concerning the need to fish in 1978 for license renewal in 1979.

3. The manner in which the present license freeze was implemented nullified any beneficial effect and in fact appeared to worsen the license situation.

4. Total Strait landings remained low (scallop closure effect?) and the relatively small frequency of four-year old scallops suggest that they will not recover in 1979. Landings can be expected to remain low until a significant increase in recruitment occurs, of which there are as yet no indications.

5. Meat counts per pound are relatively low as a result of the lack of new recruits, and not apparently because of voluntary culling of young scallops by the fishermen.

6. The relationship between meat weight/gonad weight and temperature is not known. although annual differences in meat/gonad weights for specific months are evident. Since timing of a closure period, if introduced, is preferable when yield is reduced, knowledge of this relationship is essential. The possible development of a gonad fishery would also benefit from such information.

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TABLE 1. Monthly Scallop Landings in Northumberland Strait in 1976, 1977, and 1978 (values are suggested to underestimates of actual landings).

1976	LANDINGS (kg)		
	N.B.	N.S.	P.E.I.
April	193,708	51,429	160,447
May	488,188	5,755	424,228
June	259,730	28,745	245,879
July	73,953	119,722	353,655
August	188	57,824	118,338
September	-	18,221	71,290
October	-	16,541	73,075
November	-	4,479	26,861
December	-	-	753
Total Round Weight (kg):	1,015,767	302,716	1,474,526
Meat weight (M.T.):	122	36	178

1977			
April	59,636	6,416	34,449
May	357,204	9,758	128,345
June	261,820	3,278	105,534
July	33,290	30,761	99,178
August	-	25,896	117,971
September	-	26,462	68,878
October	-	16,190	37,347
November	-	10,370	33,522
December	-	-	-
Total Pound Weight kg	711,950	130,861	625,224
Meat weight (M.T.)	86	16	75

1978			
April	121,428	-	15,761
May	804,194	-	112,850
June	325,269	12,274	58,911
July	34,327	14,725	143,792
August	-	-	-
September	451	40,924	97,354
October	56	78,294	167,580
November	-	23,498	45,263
December	-	-	1,393
Total Round Weight kg	1,285,725*	169,715	642,904
Meat Weight (M.T.)	155*	20	77

*Estimated to be 70% meat, 30% gonad.

TABLE 2. Regional scallop landings in Northumberland Strait in 1976, 1977, and 1978.

Province	S.D. District	Lobster District	Representative Ports	1976 annual landing (round kg)	1977 annual landing (round kg)	1978 annual landing (round kg)
Nova Scotia	11	7	Caribou, Toney R., Cape John	263,840	111,358	149,061
	12	7	Lismore	1,145	9,215	900
	13	7	Bayfield, Cribben's Pt.	37,505	10,288	19,754
New Brunswick	75	8	Cape St. Louis, Kouchibouquac	120,231	66,150	50,457
	76	8	Richibucto, Richibucto Cape	338,028	152,581	211,936
	77	8	Buctouche	35,934	34,317	93,762
	78	8	Shediac, Cape Bald	125,752	92,634	98,890*
	80A	8	Murry Corner, Cape Tormentine	395,822	366,268	830,680*
Prince Edward Island	82A	8	Howard Cove, Miminegash	681,170	171,997	79,156
	83	8	Borden	110,285	83,499	58,614
	86	7	Wood Is., Charlottetown	241,393	176,610	186,853
	87	7	Beach Pt., Gaspereau	421,447	193,118	315,126
	88	7	Annandale	20,231	-	3,155

*Estimated to be 50% meat, 50% gonad

TABLE 3. Monthly Northumberland Strait Scallop Landings in Lobster Districts 7a and 8 in 1976, 1977, and 1978

Month	1976		1977		1978	
	eastern 7a	western 8	eastern 7a	western 8	eastern 7a	western 8
January						
February						
March						
April	121,416	284,168	7,961	92,270	8,683	128,506
May	24,827	893,344	33,303	462,004	38,421	878,623
June	61,645	472,709	19,648	350,984	32,117	364,337
July	416,222	131,108	110,004	53,225	158,517	34,327
August	170,889	5,461	143,374	493	-	-
September	87,557	1,954	97,340	-	138,278	451
October	80,362	9,254	53,537	-	240,709	5,221
November	22,869	8,471	35,422	8,470	58,124	10,637
December	-	753	-	-	-	1,393
Total (round kg)	985,787*	1,807,222	500,589*	967,446	671,694	1,423,495**
Meat(MT)	119*	218	60*	117	81	172**

*Suggested to be underestimates of actual landings.
** May be overestimate due to landings of meat and scallops.

TABLE 4. Estimated number of boat weeks fished in 1976 in Northumberland Strait by Statistical District.

Province	Statistical district	Permits issued	Active participants	Degree of effort (weeks)					Total (boat weeks)
				< 2	2-4	4-8	8-12	> 12	
P.E.I.	82A	29	14	8	4	1		1	46
	82B						3	5	78
	83A	18	8				3		30
	85A	4	3					15	180
	86A	15	15				20	60	920
	87	144	80				12		240
	88	43	42						
Totals		253	162						1494
N.S.	11	51	38	3	7		8	20	347
	12	12	3		3				9
	13	30	16	9	7				39
	14							2	24
	43B	2	2						
	45								44
	46	8	6		4	2			
Totals		103	65						463
N.B.	75	14	11		6	5			48
	76	32	28		4	6	24	10	408
	77	16	14			4	9	1	126
	78	13	6	1	3	2			23
	80A	57	43		10	24	9		264
Totals		132	102						869

TABLE 5. Numbers of licensed and active scallop fishermen in the three regions of Northumberland Strait in 1976-78.

	West & Central	East	Combined
1976			
# licensed	179	309	488
# actual participants	124	205	329
1977			
# licensed	215	207	422
# actual participants	118	110	228
1978			
# licensed	236	317	553
# actual participants	140 (estimate)	133	273

TABLE 6. Height-weight relationship of Kotzebue Island Strait sea scallops. $\log_e W = A + B \log_e H$. n = no. of scallops; WM = wet meat; WG = wet gonad, DM = dry meat; DG = dry gonad.

		1976			1978											
		East			West			Central			East			Combined		
		n	A	B	n	A	B	n	A	B	n	A	B	n	A	B
April	WM										50	-10.090	2.624	50	-10.090	2.624
	WG	-	-	-	-	-	-	-	-	-	50	-12.491	3.141	50	-12.491	3.141
	DM										50	-11.888	2.882	50	-11.888	2.882
	DG										50	-14.566	3.145	50	-14.566	3.145
May	WM	330	-10.85	2.95	294	-9.787	2.722	384	-9.586	2.691	100	-10.254	2.850	778	-9.843	2.850
	WG	-	-	-	294	-16.551	3.929	384	-12.735	3.273	100	-12.082	3.091	778	-13.364	3.091
	DM	-	-	-	294	-11.369	2.736	384	-11.119	2.705	100	-12.212	2.935	778	-11.347	2.935
	DG	-	-	-	294	-19.904	4.225	384	-14.913	3.368	100	-15.612	3.364	778	-15.346	3.364
June	WM	280	-11.86	3.16	247	-11.141	3.034	94	-12.429	3.299	277	-11.319	3.065	620	-11.685	3.147
	WG	-	-	-	247	-14.599	3.605	94	-14.901	3.685	277	-11.312	2.946	620	-12.815	3.241
	DM	-	-	-	247	-12.467	2.993	94	-12.844	3.070	277	-12.683	3.033	620	-12.858	3.075
	DG	-	-	-	247	-17.237	3.762	94	-11.860	2.647	277	-13.083	2.942	620	-13.560	3.007
July	WM	1,198	-11.19	2.86							271	-12.101	3.216	271	-12.101	3.216
	WG	-	-	-	-	-	-	-	-	-	271	-20.733	4.954	271	-20.733	4.954
	DM	-	-	-							271	-13.253	3.135	271	-13.253	3.135
	DG	-	-	-							271	-19.664	4.366	271	-19.664	4.366
August	WM	633	-7.62	2.21	401	-12.124	3.209	249	-12.200	3.220	750	-11.198	2.998	1400	-11.639	3.098
	WG	-	-	-	401	-14.960	3.802	249	-11.045	2.954	750	-13.254	3.348	1400	-13.857	3.521
	DM	-	-	-	401	-12.828	3.022	249	-14.055	3.272	750	-12.814	3.016	1400	-13.073	3.071
	DG	-	-	-	401	-16.820	3.857	249	-12.637	2.931	750	-13.592	3.048	1400	-15.105	3.428
Sept.	WM	609	-7.13	2.15							344	-10.546	2.874	344	-10.546	2.874
	WG				-	-	-	-	-	-	344	-11.320	2.771	344	-11.320	2.771
	DM										344	-12.452	2.943	344	-12.452	2.943
	DG										344	-14.567	2.934	344	-14.567	2.934
Oct.	WM	620	-8.20	2.39							150	-10.709	2.941	150	-10.709	2.941
	WG				-	-	-	-	-	-	150	-11.238	2.718	150	-11.238	2.718
	DM										150	-12.497	2.985	150	-12.497	2.985
	DG										150	-19.373	3.908	150	-19.373	3.908
Nov.	WM										50	-10.948	2.974	50	-10.948	2.974
	WG	-	-	-	-	-	-	-	-	-	50	-12.007	2.858	50	-12.007	2.858
	DM										50	-13.306	3.134	50	-13.306	3.134
	DG										50	-20.158	4.052	50	-20.158	4.052

TABLE 7 . Von Bertalanffy growth parameters for meat weight and shell size in Northumberland Strait scallop samples

$$L = L_\infty (1 - e^{-k[t-t_o]})$$

	West	Central	East	Combined
L_∞	127.78	114.82	127.97	126.17
W_∞*	32.56	23.64	32.73	32.12
t_o	-0.460	-0.229	-1.067	-0.362
k	0.216	0.276	0.194	0.206

*Calculated from $\log_e W = -11.067 + 3.00 \log_e H$ (average values from combined totals in Table 6).

TABLE 8. Estimated numbers of scallops at age from populations in the eastern region of Northumberland Strait. Data derived from unrelated experimental studies (1974), resource surveys (1976), and commercial height frequency measurements (1977, 1978).

Age (Yr.)	1974		1975		1976		1977		1978	
	#	%	#	%	#	%	#	%	#	%
0	1	0.3	-	-	21	0.1	-	-	-	-
1	14	3.5	-	-	75	0.5	-	-	135	0.5
2	34	8.4	-	-	390	2.4	4	0.4	466	1.6
3	61	15.1	-	-	1,633	9.9	79	7.2	1,191	4.1
4	89	22.0	-	-	4,308	26.0	311	28.4	3,106	10.8
5	84	20.8	-	-	3,303	19.9	136	12.4	7,683	26.7
6	38	9.4	-	-	2,998	18.1	163	14.9	6,404	22.2
7	35	8.2	-	-	2,001	12.1	149	13.6	4,094	14.2
8	22	5.5	-	-	1,061	6.4	96	8.8	2,597	9.0
9	5	1.2	-	-	492	3.0	39	3.6	1,350	4.7
10	14	3.5	-	-	6	0.0	21	1.9	702	2.4
11	1	0.3	-	-	164	1.0	-	-	1,088	3.8
12	2	0.5	-	-	2	0.0	-	-		
13	2	0.5	-	-	-	-	-	-		
14	1	0.3	-	-	-	-	-	-		
15	1	0.3	-	-	-	-	-	-		
16+	-	-	-	-	129	0.7	99	9.0		
TOTALS:	404		-		16,583		1,097		28,816	

TABLE 9. Estimates of Z and F for 1976/77 in the eastern Northumberland Strait, using the equation $Zt = \log N_0/N_1$, with data in Table 7. M = 0.1

Age	Z	F
3-4	-	-
4-5	0.74	0.64
5-6	0.29	0.19
6-7	0.29	0.19
7-8	0.32	0.22
8-9	0.59	0.49
9-10	0.44	0.34

TABLE 10. Avg. meat yield (gm) for a 4-gang Gulf tumble drag per tow. n = no. tows; N = avg. no. scallops; Y = yield.

	West			Central			East		
Month	n	N	Y	n	N	Y	n	N	Y
May	8	206	2,061	22	186	1,564	6	51	510
June	18	225	2,545	6	189	1,574	32	131	1,380
July	-	-	-	-	-	-	65	127	1,413
August	25	40	358	35	85	614	89	106	1,103
September	-	-	-	-	-	-	35	134	1,315
October	-	-	-	-	-	-	15	119	1,147

TABLE 11. Eastern Northumberland Strait scallop landings in 1978 as reported by port samplers.

DATE	NO. BOATS	AVG. CATCH/BOAT	AVG. NO. TOWS	AVG. CATCH/TOW (lb.)	AVG. CATCH/TOW (kg)
Woods Island - 34 boats					
Sept. 16	4	98.3 ± 5.6	34.8 ± 1.0	2.8	1.27
18	4	59.3 ± 6.4	28.5 ± 6.4	2.1	0.95
19	4	105.8 ± 14.3	37.8 ± 1.5	2.8	1.27
20	5	75.0 ± 16.2	33.6 ± 6.9	2.2	1.00
21	18	98.9 ± 6.7	40.1 ± 2.1	2.5	1.13
22	14	73.4 ± 11.5	34.8 ± 1.6	2.1	0.95
23	8	76.3 ± 11.3	39.0 ± 2.3	2.0	0.91
25	6	116.3 ± 21.8			
26	21	91.7 ± 8.8	34.6 ± 1.7	2.7	1.22
27	19	93.6 ± 5.7	33.9 ± 0.6	2.8	1.27
28	18	115.4 ± 10.0	34.2 ± 1.6	3.4	1.54
29	18	55.1 ± 6.3	24.3 ± 1.5	2.2	1.00
Beach Point - 27 boats					
Sept. 16	-	-			
18	15	54.9 ± 6.4			
19	-	-			
20	14	75.0 ± 11.0			
21	11	62.9 ± 13.5			
22	13	113.3 ± 13.5			
23	7	120.4 ± 17.3			
25	-	-			
26	9	120.6 ± 25.4			
27	10	107.3 ± 11.1			
28	11	101.3 ± 18.1			
29	11	105.8 ± 8.1			
Beach Point - 16 boats					
Oct. 2	3	76.7 ± 15.9			
3	-	-			
4	2	44.0 ± 22.0			
5	1	78.0			
6	11	75.6 ± 11.16			
7	5	62.6 ± 11.75			
11	8	105.6 ± 9.1	40.4 ± 1.7	2.6	1.18
12	10	117.7 ± 11.1	37.8 ± 2.0	3.1	1.41
13	4	49.8 ± 8.5	20.5 ± 4.2	2.4	1.09
14	7	96.4 ± 13.0	35.0 ± 2.2	2.8	1.27
Pictou - 17 boats					
Sept. 16	17	68.1 ± 9.7			
17	15	58.6 ± 8.2			
18	7	67.6 ± 14.6			
19	3	78.7 ± 47.4			
20	1	41.0			

TABLE 12. Estimated scallop abundance in Northumberland Strait for each Region.

	West	Centre	East
Mean no. scallops/tow	215	148	123
Total area (km^2)	32.2	18.6	73.6
Total area/area covered per tow	11,587	6,693	26,484
Number scallops ($\times 10^{-3}$)	2,491	991	3,257
Estimated catchability* (%)	0.154	0.154	0.154
Total estimated no. scallops ($\times 10^{-6}$)	16.2	6.4	21.2

*from Caddy (1971)

TABLE 13. Age-specific yields (MT meat) in eastern Northumberland Strait (P.E.I) in 1978.

Age (yr.)	Frequency (%)	Meat wt. (g)	Proportion (freq. x meat wt.)	% of total yield	Yield (MT)
3	4.1	4.9	20.1	1.5	1.2
4	10.8	7.7	83.2	6.4	5.0
5	26.7	10.6	283.0	21.7	16.8
6	22.2	13.4	297.5	22.8	17.7
7	14.2	15.6	221.5	17.0	13.2
8	9.0	13.1	162.9	12.5	9.7
9	4.7	20.2	94.9	7.3	5.7
10	2.4	21.9	52.6	4.0	3.1
11+	3.8	≈ 23.0	87.4	6.7	5.2
TOTAL	97.9		1302.4	99.9	77.6

TABLE 14. Average meat counts (and sample range) per pound for scallops landed monthly in the three regions of Northumberland Strait in 1978. n = no.of pounds measured.

	West		Central		East	
	N	Count	N	Count	N	Count
May	23	33.7 (25.4-42.6)	19	34.9 (26.3-41.7)	8	21.2 (17.2-23.6)
June	24	26.8 (20.0-32.7)	20	29.7 (20.8-39.0)	43	30.8 (23.6-37.2)
July	-	-	-		67	31.3 (19.0-48.1)
August	3	39.0 (34.5-45.3)	28	31.7 (24.5-50.8)	82	33.1 (23.6-46.3)
Sept.	-	-	-	-	31	35.2 (23.6-45.4)
Oct.	-	-	-	-	11	35.6 (30.8-41.7)

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Figure 1. Annual scallop landings (10^{-3} lb) by province in the three regions of Northumberland Strait.

Figure 2. Annual numbers of self-identified, "active" scallop fishermen in Northumberland Strait. The actual census terminated in 1972 but was reintroduced for one year in 1976. Est. = estimated number of fishermen in 1978.

Figure 3. Annual numbers of self-identified, "active" scallop fishermen in each province in the three regions of Northumberland Strait.

Figure 4. Seasonal fluctuations in meat (1976 and 1978) and gonad (1978) wet weights (g) for 90 mm scallops in the three regions of Northumberland Strait. Values were calculated from the data in Table 6.

Figure 5. Von Bertalanffy growth curves for Maritime scallop stocks (A) and the three regions of Northumberland Strait (B). Equations are presented in Table 2.

Figure 6. Yields and yield isopleths (kg) per 10,000 recruits calculated for Northumberland Strait scallops based on the combined Von Bertalanffy growth parameters in Table 7. t'_o = age (years) of first capture. F = fishing mortality.

Figure 7. Seasonal height frequencies of the mean number of scallops fished per tow by a 4-gang tumble drag in the three regions of Northumberland Strait. N = number of tows.

Figure 8. Relative height frequencies of scallops fished in the three regions of Northumberland Strait.

Figure 9. Potential productive scallop ground over the past 20 years in Northumberland Strait. Not all areas may have commercial scallop densities in any one year

FIG.1: ANNUAL SCALLOP LANDINGS

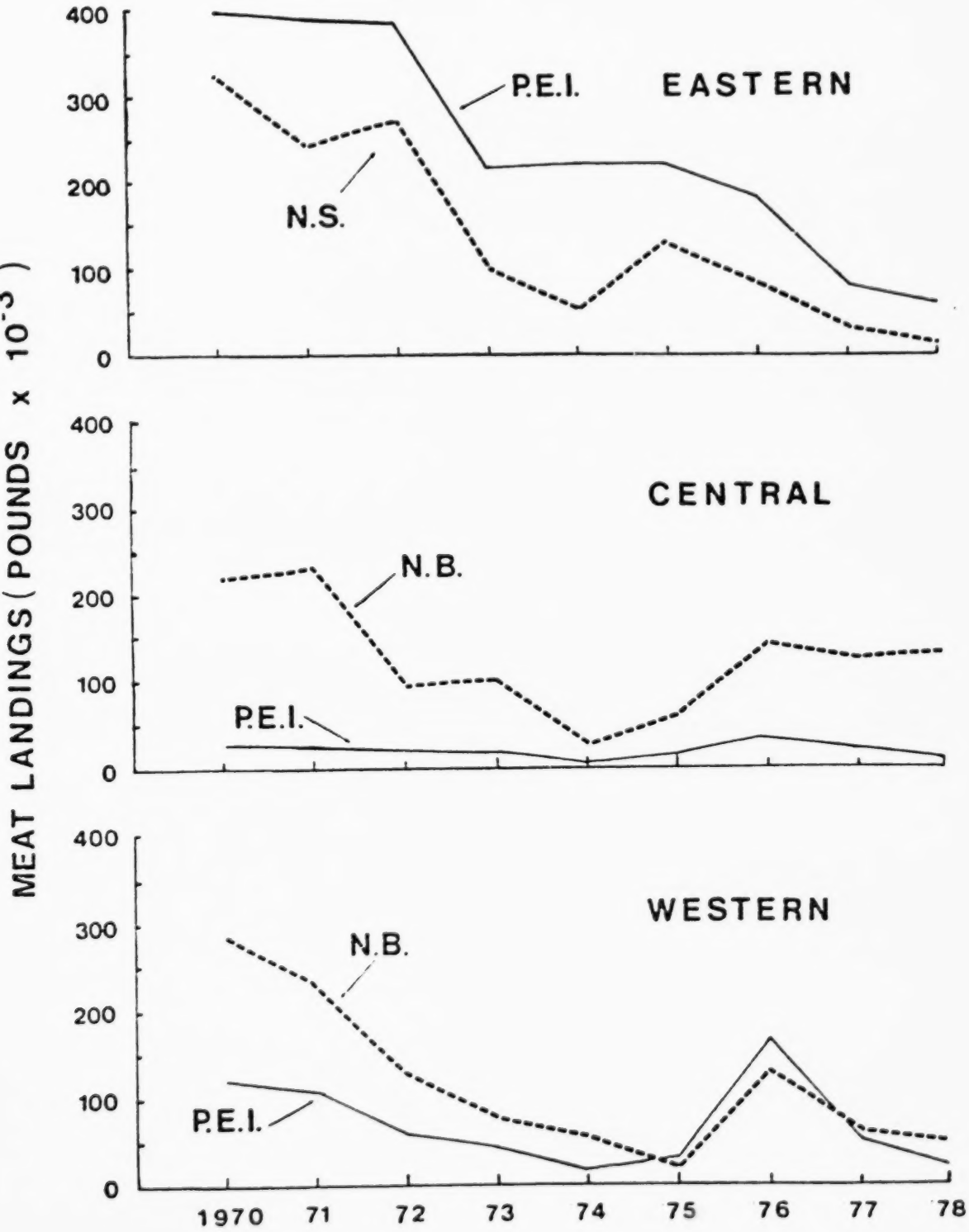

FIG. 2 : 'ACTIVE' FISHERMEN

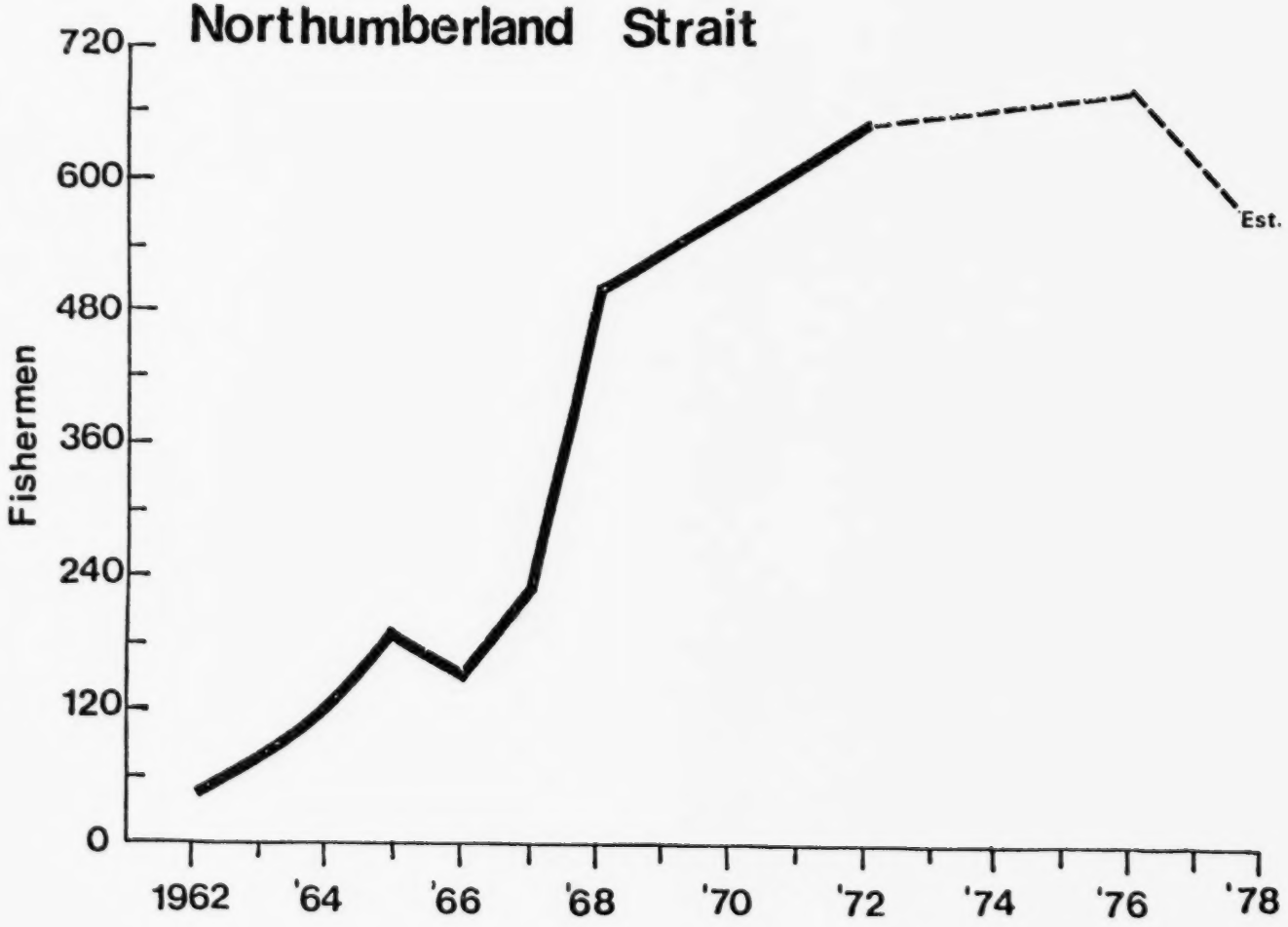

FIG.3: 'ACTIVE' FISHERMEN

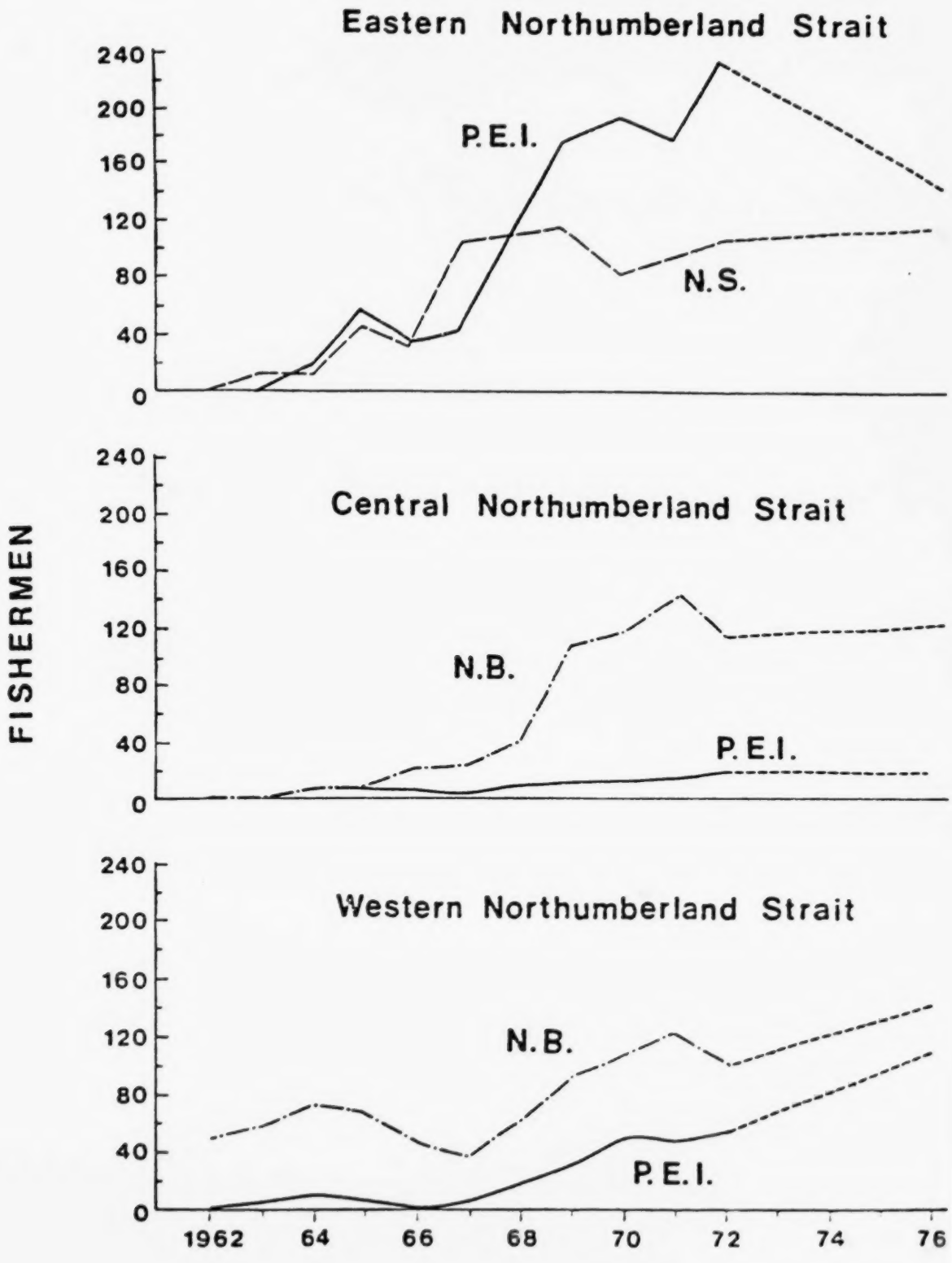

FIG. 4: SEASONAL FLUCTUATIONS IN MEAT AND GONAD WET WEIGHTS FOR A 90 mm NORTHUMBERLAND STRAIT SCALLOP

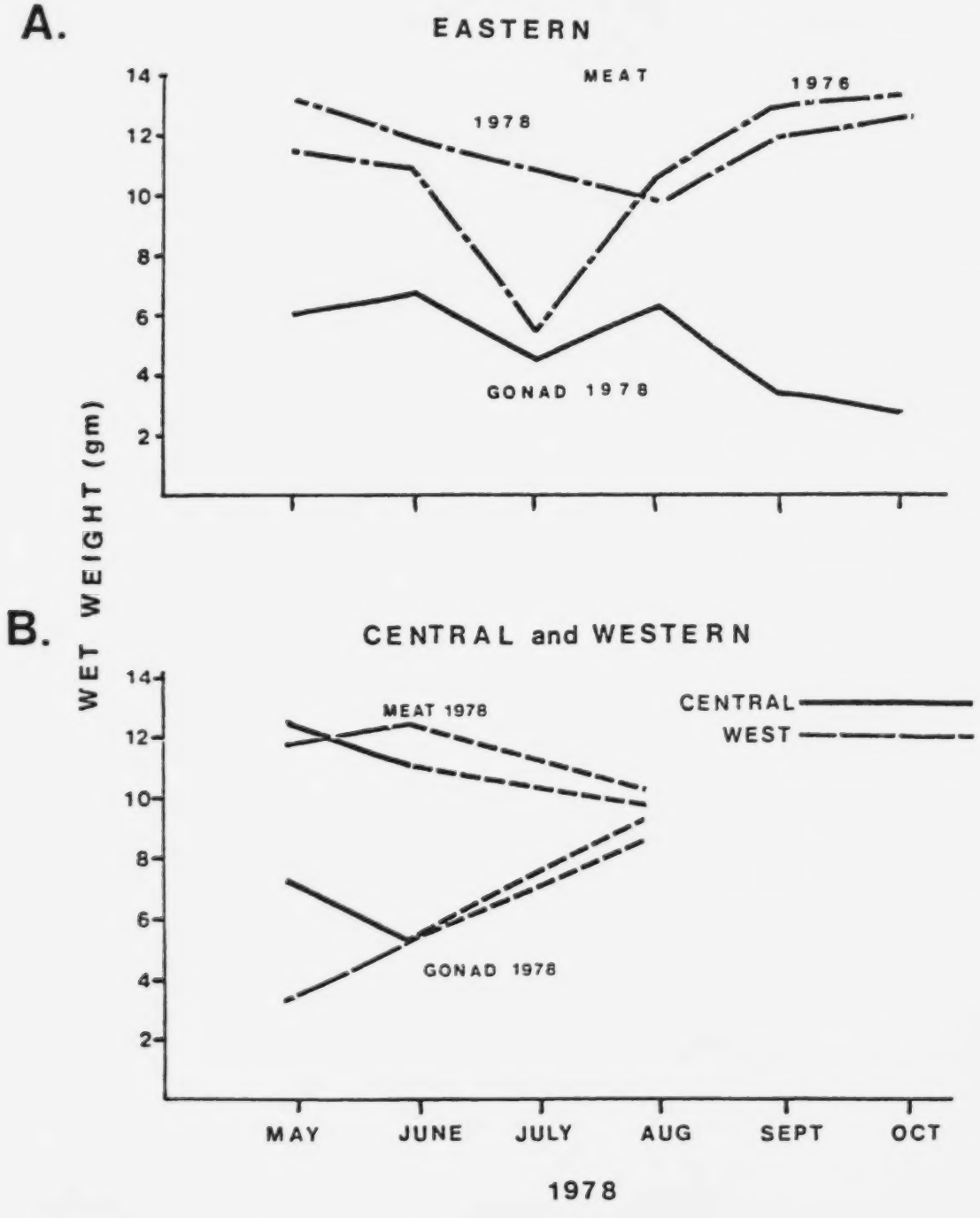

FIG. 5: GROWTH CURVES

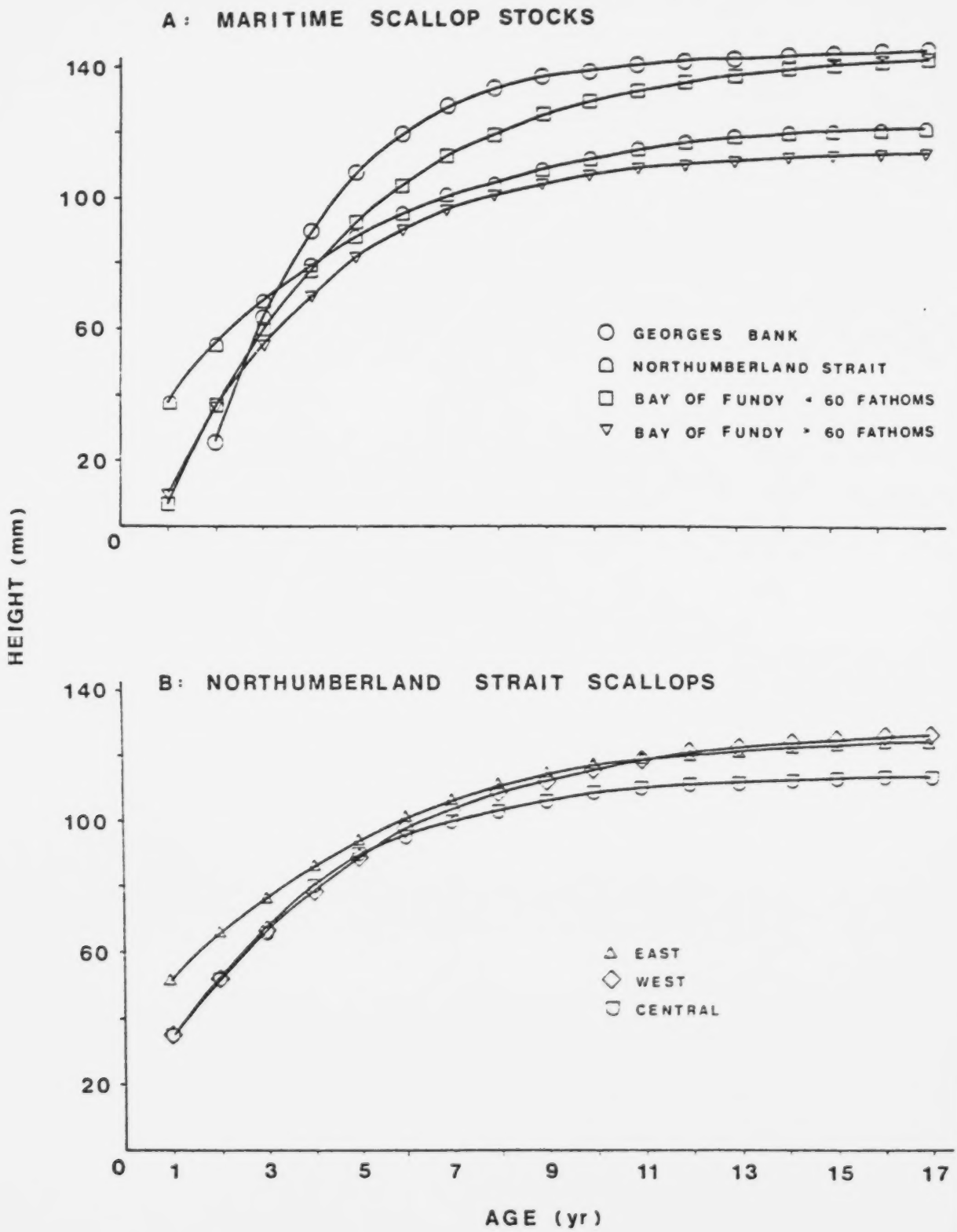

FIG. 6: YIELD (kg) PER 10,000 RECRUITS

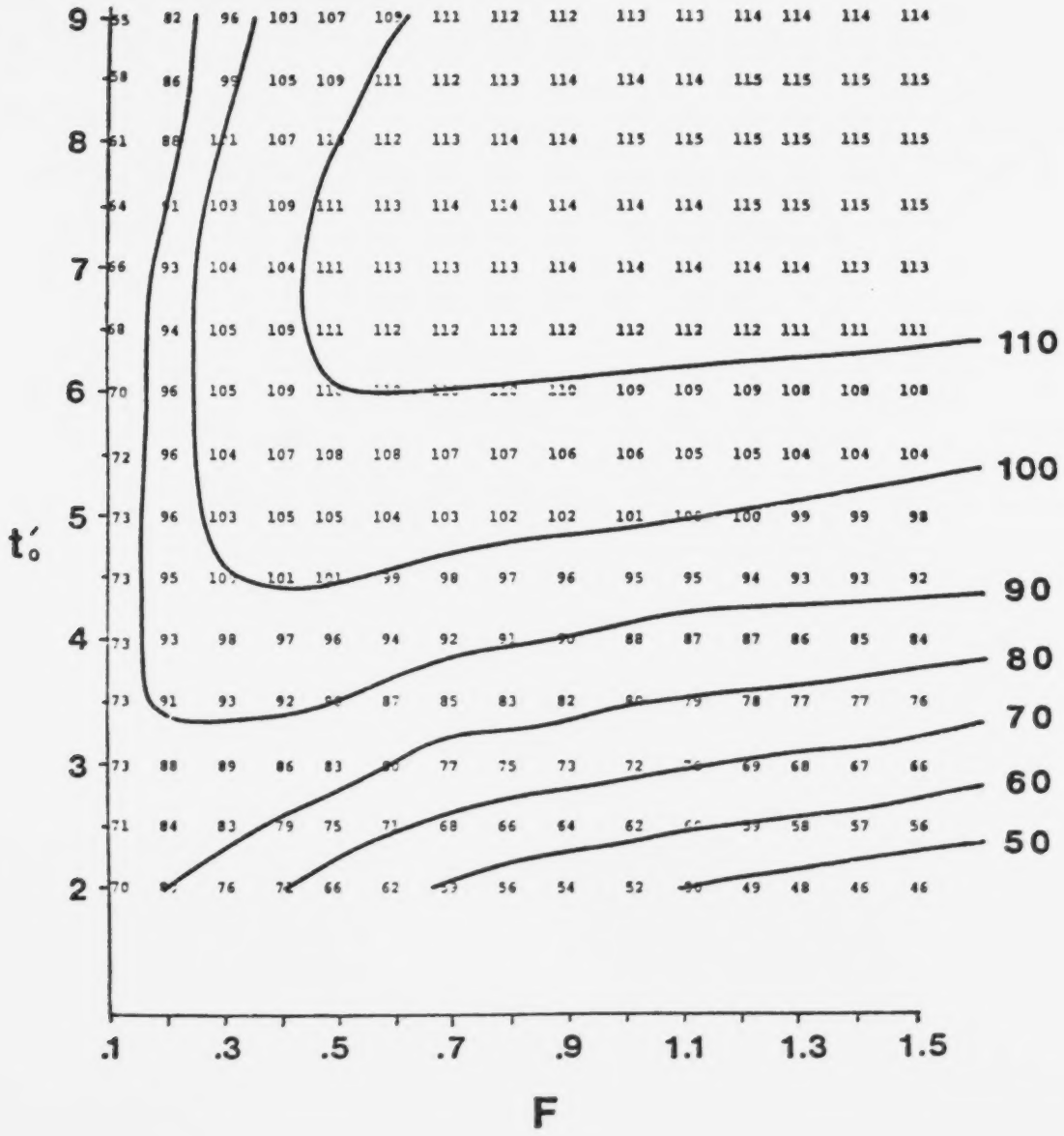

FIG. 7: HEIGHT FREQUENCIES, 1978

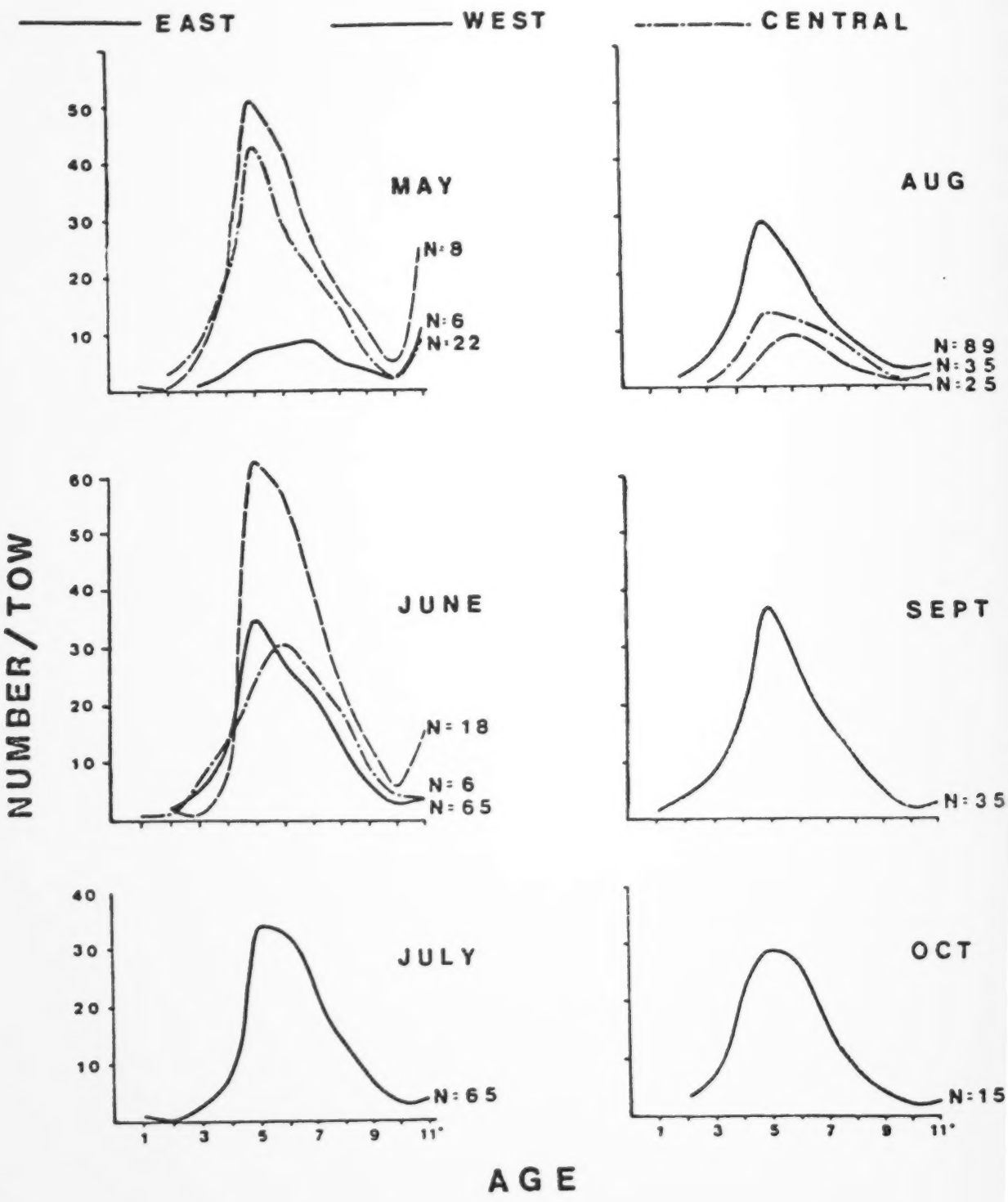

FIG. 8: HEIGHT FREQUENCIES, 1978

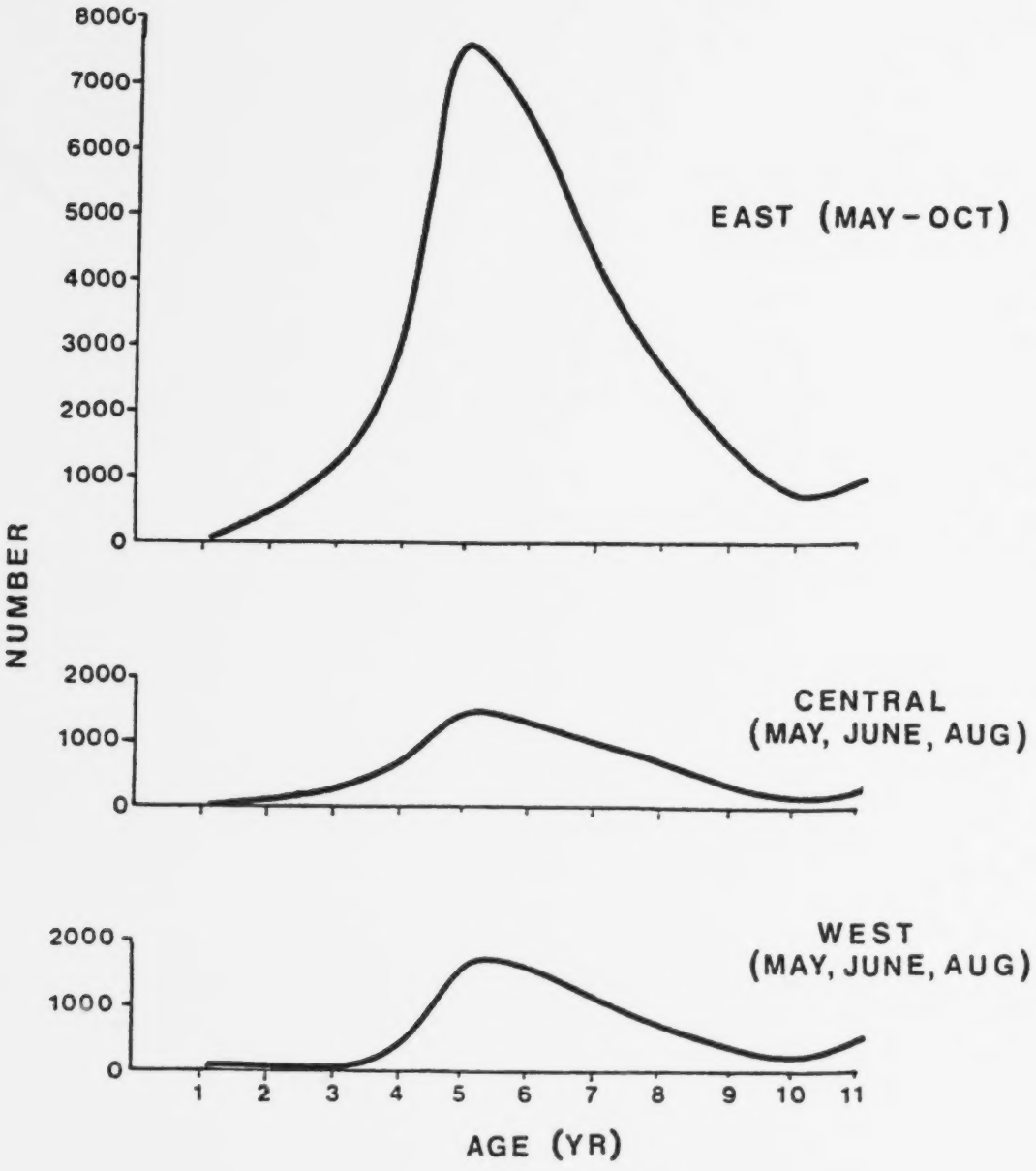

FIG. 9: POTENTIAL PRODUCTIVE SCALLOP GROUNDS